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The Probability of Using Car Sharing in Bangkok

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Abstract—This research aimed to examine the factors influencing the probability of using car sharing in Bangkok. The study used 612 observations from a survey questionnaire. The data were analyzed using multiple linear regression under the concept of logistic regression. In particular, socio-demographic, travel behavior and car-sharing preference attributes were tested to interpret interest in car-sharing. The results revealed the factors influencing the probability of using car sharing were mode of travel, purpose of journey, walking distance, ride-hailing experience, car-sharing experience, expected purpose to choose car-sharing, expected reason to use car-sharing, acceptable longest waiting time for shared-car availability, and car-sharing service price.

Keywords- Car-sharing, Demand estimation, Probability

I. INTRODUCTION

Passenger Transport in Bangkok is dominated by personal vehicles, primarily cars, pickup trucks, and motorcycles. From the travel survey of people in Bangkok and perimeter provinces in 2017, the majority of the sample group travelled by private car, accounting for 39.90%, and followed by public transport and private motorcycles for 29.50% and 23.80%, respectively. The number of private vehicles in Bangkok was increasing at an average 8% - 10% per year from 2008 – 2019 and this trend is expected to continue [1].

Bangkok has been suffering from terrible transport problems including traffic congestion, pollution, and parking problems. To reverse these negative trends, many approaches have been adopted such as developing an urban-train network, building more roads, and using alternative fuel vehicles. However, these solutions seem to have had no significant effect on the sustainability of the transport system in Bangkok. Fortunately, there is one emerging solution for urban transport solutions, namely car sharing. Numerous studies have confirmed that it contributes to a more efficient transport solution by reducing the number of vehicles, lowering demand for parking space, and eliminating fixed costs of car ownership. Furthermore, car-sharing systems lead to reductions in physical and economic resource consumption, and energy and environmental impacts [2].

However, since car sharing is a new phenomenon in Bangkok, an estimate of current travel trends and a forecast of future travel requirements is important for both business and government in order to consider transportation planning and capital investment. This study aimed to investigate the factors influencing the probability of car-sharing services being used in Bangkok.

II. LITERATURE REVIEW

Factors influencing the probability of using car-sharing schemes could be categorized into three aspects as follow.

A. Personal factors

Many researchers have attempted to uncover socio-economic influences on the decision to use car-sharing services, with inconsistent conclusions. Some studies indicated that men were likely to join car-sharing schemes than women [3-6]. However, a number of studies had the opposite findings [7-10]. Gender attribute was not found to be statistically significant [11-12].

The empirical studies found that a customer's age had a bearing on the intention to use car sharing. Most of the studies claimed that younger adults tend to be interested in car sharing [4-5, 13]. On the other hand, reference [14] found that the older the person, the more opportunity to use a shared car. However, reference [11] found that age does not have any effect on the decision to choose a shared car.

The influence of income on the potential to use car-sharing remains unclear. Some studies found that people who have high income are more willing to join car sharing than others [6, 9, 10, 13]. In contrast, reference [15-16] found that people who have medium to low income are more willing to join car-sharing schemes.

Employment status and occupation have significantly influenced the decision to use car-sharing services [4].

Reference [17] found that people who are employed full-time or self-employed have greater propensity to use car-sharing services than other groups because they may be using the service for work-related activities. In contrast, reference [8] found that people who are interested in car-sharing tend to be non-office workers or university students.

Many studies found that the number of cars available in household also affects decision to use car sharing. It is quite clear that non or low levels of car availability tend to be high attractiveness of car sharing [14, 18-19].

A number of other personal's factors affect the propensity to choose car sharing. Reference [20] found a relationship between types of housing and the decision to use car sharing. They found that people who live in their own home preferred to choose car-sharing more than other groups. Reference [5] studied monthly transportation expenditure. The results showed that with the increase in monthly transportation expenditure, more consumers prefer to choose car sharing.

B. Travel behavior

Trip characteristics also affect the intention to use car sharing. Reference [11] found the most significant factor that affects the propensity towards the car-sharing system was travel distance. Reference [3, 5, 14] found that the longer distance to travel, the greater probability to choose a personal car. This result is inconsistent with reference [11] that found long travel distances reduce the propensity for joining car-sharing system.

Moreover, trip frequency plays a crucial role in choice of travel. Reference [4, 7, 11] found that people tend to drive their own car instead of a shared car if they have frequent weekly trips.

Reference [15] found that people who use taxis for trips related to social activities tend to join car-sharing schemes. Reference [4] found that users traveling for work purposes are less willing to switch to car sharing.

The findings of the relationship between the current mode of travel and the intention to use car sharing were relatively constant. Reference [15] found that car sharing is attractive to people who travel mainly by public transport such as bus, trolley or tram for their commute. This result was consistent with reference [11]'s study, which indicated that commuters who travel by bus have more interest in car sharing. Reference [16] found that commuters who travel by taxi are more likely to join car-sharing schemes. Reference [5] found that people who usually take the subway, bus or bike are more willing to use car sharing.

C. Car-sharing attributes

Many studies have found that travel cost and time have a strong effect on whether to use car sharing. The probability of selecting car-sharing decreases when the cost variables of car sharing, such as deposits to join the system, membership rate fees, and hourly rates increase [9, 12, 14, 20]. Other studies found that parking costs also affect the probability of using car sharing [21-22].

Reference [14, 21] found that time pressure has a negative and bigger impact on the likelihood of using car sharing. Reference [7, 21] found that people favor car sharing if the access time to car-sharing and waiting time are reduced. Reference [20] found that people were generally willing to wait for the availability of shared car approximately 15-20 minutes and the access time to car-sharing approximately 5-7 minutes. Reference [21] found that the probability of using car sharing tended to be more elastic with respect to waiting time rather than access time and travel time.

Parking location is also an important factor in the car sharing decision [7, 22]. Reference [23] found that the better a place of parking location is accessible, the less likely a household is to own a car. Reference [23] found that the walking distance from parking location to/from the workplace also impacts the decision of whether to use a shared car. Reference [6] found that placing a new station for car-sharing system outside a major technology firm will increase the number of adopters the most. The distance from car-sharing parking to transit bus also influences the decision on using car-sharing. Reference [19] found that the likelihood of recruiting increased by 53% in the first 250 meters and by 25% between 250 and 500 meters.

The availability of a shared car is a key factor in the decision to use car sharing [12]. Reference [24] found that fleet size and vehicle distribution also significantly influence the choice of shared car and activity-travel pattern. Moreover, the level of services also influences the market penetration of car sharing [11].

Essentially, the awareness of car sharing is crucial for the probability of choosing car-sharing service [17]. Likewise, reference [11] indicated that car-sharing demand is affected by the level of knowledge of the service itself. Reference [8] found that people tend to use car sharing for leisure or personal purposes.

III. RESEARCH METHODOLOGY

The present work employed the survey research to describe the existence of a relationship between socio-economics, travel behavior, car-sharing preference and customer decisions in terms of the propensity of car-sharing. For the data analysis, multiple linear regression under the concept of logistic regression analysis was used for determining the factors affecting the propensity to use car sharing of the target population.

A. Study Area

Bangkok was selected as the study area of this research for two main reasons. Firstly, Bangkok is a business area that millions of people travel within and across every day, with particularly bad traffic conditions and insufficient parking space. Secondly, the Bangkok area has good public transportation networks, which is one of the key success factors for a car-sharing system.

B. Questionnaire

This study used a questionnaire comprising three parts: socio-economics, travel behavior, and car-sharing preference. The last part also included three price scenarios, where respondents were asked about how likely they were using car sharing, ranking from 0-100, with 0 referring to 'definitely not use' and 100 referring to 'definitely use'.

C. Sample and Data collection

Before running the main survey, a pilot survey of 30 respondents was performed to test the questionnaire. The main questionnaire survey was conducted between June and July 2020. The respondents were given a QR code of the online questionnaire, so that they were able to complete the questionnaire through an online survey on google form. The questionnaire's QR code was distributed in public places such as bus stops, shopping malls, offices, and universities. The random sampling method was applied to the target population, which was selected by age older than 18 years old living, studying, or working in Bangkok. In total, 204 respondents completed the questionnaire. However, there were three price scenarios for each respondent. Thus, there were 612 observations in total.

D. Data analysis

The data obtained from the questionnaire survey was analyzed with both descriptive and interference statistics. Multiple linear regression was implemented to investigate the factors influencing the probability of car-sharing services being used in Bangkok.

However, before running the multiple linear regression with the statistical software program IBM SPSS Statistics 21, the dependent variable (Y, the probability of car-sharing) was modified to a continuous value by multiplying by 0.99, and adding 0.5. Then, Y was transformed to log odds.

From the logistic regression theory, the logistic model predicts the logit of Y from X, and the logit is the natural logarithm (ln) of odds of Y, and odds are ratios of probabilities of Y happening to probabilities of Y not happening [25].

The extended logistic model with multiple predictors has a form

$$\text{Logit}(Y) = \log(\text{odds}) = \ln(y/(1-y)) = \alpha + \beta_1 X_1 + \ldots + \beta_n X_n \quad (1)$$

Thus, this research applied the concept of logistic model, and constructed the multiple linear regression as

$$\ln(y/(1-y)) = \alpha + \beta_1 X_1 + \ldots + \beta_n X_n \quad (2)$$

To interpret the result, odds ratio for the transformed covariate was

$$y/(1-y) = \exp(\beta) \quad (3)$$

IV. Results

A. Socio-economic status of respondents

Socio-economic were analyzed and are presented in table I. The majority of the respondents were female (63.2%), with 36.8% male. Most of the respondents (69.5%) were aged between 20 and 40, which was expected to be the age group of target users of car-sharing services. The main occupation group was office staff or other full-time workers (61.3%), and their personal monthly income was less than 20,000 Baht (37.7%). Twenty-four percent of the participants were living with three people in their household (total of four people per household). Most of the respondents (42.2%) possessed one car, and held a driving license (72.5%).

B. Travel behavior and car-sharing preference

As shown in table II, most of the respondents used a personal car (as a driver), accounting for 53.4%, followed by public transport (34.8%), and personal car as a passenger (11.8%), respectively. The largest group of participants (33.3%) traveled five days a week and the second largest group (26%) traveled seven days a week (26.0%). The majority of them (64.7%) travelled alone. The travel purpose was mainly concentrated in work or study (88.2%). The average travel distance was 27.11 kilometers, average travel duration was 74.15 minutes, average walking distance from home to car park or bus stop was 183.50 meters, average walking distance from office / university to car park or bus stop was 212.09 meters, and the daily travel expenditure was 139.92 Baht. The majority of the respondents had an experience of using ride-hailing services or mobile-app taxis (79.9%).

TABLE I. The socio-economic of the respondents

Socio-economic		Data type	Percentage
Gender	Male	Categorical data	36.8
	Female*		63.2
Age	18 - 20 years old*	Categorical data	2.5
	20 – 40 years old		69.5
	41 - 60 years old		26.5
	More than 60 years old		1.5
Employment	Students*	Categorical data	13.7
	Business owner / Freelance		12.3
	Office staff / Full time		61.3
	Part-time		2.5
	Retired / Unemployed		10.2

ersonal monthly income	Less than 20,000 Baht*	Categorical data	37.7
	20,000 – 40,000 Baht		33.8
	40,001 – 60,000 Baht		16.2
	More than 60,000 Baht		12.3
Number of residents in a household	Living alone	Scale data	13.7
	2 People		22.5
	3 People		17.5
	4 People		24.0
	5 People		12.2
	More than 5 people		9.8
Number of owned private cars	Zero	Scale data	35.8
	1 Car		42.2
	2 Cars		13.2
	3 Cars		5.9
	More than 3 cars		2.9
Driving license holder	Yes	Categorical data	72.5
	No*		27.5

* is the reference category used in the linear regression model

TABLE II. Travel behavior of the respondents

Variable		Data type	Percentage
Mode of travel	Personal car (Driver)*	Categorical data	53.4
	Personal car (Passenger)		11.8
	Public transport		34.8
Weekly travel frequency	1 day	Scale data	1.5
	2 days		6.4
	3 days		8.3
	4 days		5.4
	5 days		33.3
	6 days		19.1
	7 days		26.0
Number of fellows	None	Scale data	64.7
	1 people		25.5
	2 people		7.5
	3 people		1.0
	4 people		1.5
Travel purpose	Work or study	Categorical data	88.2
	Visit friends or family		1.5
	Travel or relax		2.5
	Shopping		7.0
	Visit doctor		1.0
Travel distance (km.)		Scale data	$\bar{x}$ = 27.11, S.D. = 25.69
Travel duration (mins)		Scale data	$\bar{x}$ = 74.15, S.D. = 69.26
Walking distance from home to car park or bus stop (m.)		Scale data	$\bar{x}$ = 183.50, S.D. = 350.42
Walking distance from office / university to car park / bus stop (m.)		Scale data	$\bar{x}$ = 212.09, S.D. = 377.13
Daily travel cost (Baht)		Scale data	$\bar{x}$ = 139.92, S.D. = 133.91
Ride-hailing experience	Yes	Categorical data	79.9
	No*		20.1

* is the reference category used in the linear regression model

Table III shows customer's preference of car sharing. Most of the respondents (62.3%) were unaware of car sharing, and only 8.8% of the respondents had experienced car-sharing services. The main expected purpose of using car-sharing was work or study (45.1%). The majority of the respondents indicated that they will use car-sharing to replace the current mode of travel. An average acceptable longest distance from car-sharing drop-point to their home or workplace was 458.98 meters, and an acceptable longest waiting time for shared-car availability was 19.52 minutes.

TABLE III. Car-sharing preference

Variable		Data type	Percentage
Aware of car-sharing	Yes	Categorical data	37.7
	No*		62.3
Car-sharing experience	Yes	Categorical data	8.8
	No*		91.2
Expected purpose for using car-sharing	Work or study*	Categorical data	45.1
	Visit friends or family		6.4
	Travel or relax		27.9
	Shopping		10.3
	Visit doctor		9.8
	Others		0.5
Expected reason for using car sharing	Replace current mode*	Categorical data	39.7
	Use for travel during the day		24.0
	Use for connecting to other modes		33.3
	Others		2.9
Longest walking distance (m.)		Scale data	$\bar{x}$ = 458.98, S.D. = 847.71
Longest waiting time (min.)		Scale data	$\bar{x}$ = 19.52, S.D. = 12.01

* is the reference category used in the linear regression model

C. Probability of using car-sharing

As shown in Figure 1, 22.2% of the respondents answered that they will 50% probably use car sharing, about 17.2% were definitely not using car-sharing, and 6.2% will definitely use car sharing. The results indicated that most people are reluctant to use the new service.

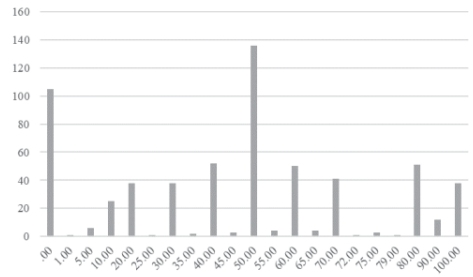

Figure 1. Frequency of the probability of using car-sharing

D. Multiple linear regression

Multiple linear regression analysis was performed in order to understand the significant factors influencing the intention to use car-sharing. There were three groups of independent variables: socio-economic, travel behavior and car-sharing preference. The dependent variable was the probability of using car sharing, which was transformed to log odds.

As shown in Table I, II and III, the data were categorized into two types: categorical data, which were transformed to a dummy variable, and scale data, which could be used for the analysis directly without transforming. Also, the variables with the star were the reference groups for the multiple linear regression analysis.

Before performing multiple linear regression analysis, the collinearity statistic, namely variation inflation factor (VIF), was tested. The results of VIF testing in table IV revealed that there was no multicollinearity problem between variables as the VIF scores in all cases were below 10 [26]. It can be concluded that there are separate effects of variables, so the further data analysis could be conducted.

The multiple linear regression analysis was run with the variables in table I, II and III. The coefficient of determination R^2 indicate the percentage of how much of the total variance explained by the independent variables was 28.4% (Table IV).

TABLE IV. Model summary

Model	R	R Square	Adjusted R Square	Std.Error of the Estimate
1	0.533	0.284	0.237	2.30677

The results of the multiple linear regression analysis were shown in table IV. Twelve variables were statistically significant, including modes of travel, travel purpose, walking distance, ride-hailing experience, car-sharing experience, expected purpose for using car sharing, expected reasons to use car sharing, acceptable longest waiting time for shared-car availability, and car-sharing service price. Table 5 shows the marginal effects which indicate the magnitude and types of association between the explanatory variables on the probability of the response variable [27]. The interpretation of each variable is as follows:

(1) Socio-economic status of the respondents did not affect the probability of using car-sharing.

(2) Mode of travel has a significant influence on the probability to use car sharing. The mode of travel of private car (as a passenger) and public transport has a negative coefficient. In other words, the people who travel by private car (as a passenger), and use both private car and public transport are less likely to use car sharing than the people who drive, approximately 27.75% and 16.0%, respectively.

(3) The traveling purpose affected the decision to use car sharing. The people who traveled for shopping were 14.8% less likely to use shared car, compared with people who traveled for work or study.

(4) The walking distance, both from home to car park or bus stop and the return trip, was significant to the customers' intention to use car-sharing. The longer walking distance, the higher probability to use car sharing.

(5) The experience of using ride-hailing service was significant, with positive coefficient and average marginal effects (AME) 19.1%. It revealed that the people who had the ride-hailing experience (or mobile-app taxi) were about 19.1% more likely to choose car sharing.

(6) The experience of using car sharing has a positive significant influence the intention to use car-sharing, with AME 27.2%. It could be interpreted that with the experience of using car sharing, the probability of choosing car sharing increase by 27.2%.

(7) The expected purpose for using car sharing was significant in relation to the propensity to use car-sharing. The people who were likely to use car sharing for travel or relaxation were found to be approximately 14.0% less likely to choose car sharing than the people who tend to use car sharing for work or study.

(8) The reasons for car-sharing had a significant impact on the customers' decision to use the service. Those people who would use car sharing for connecting to other modes of transport, and other reasons, such as when they were in hurry or it was raining, were less likely to use car sharing than the people who would use car sharing to replace the current mode of transport (11.9% and 59.7%, respectively).

(9) The acceptable longest waiting time for shared car availability was significant in relation to customers' intention to use car-sharing. The people who had more patience to wait were more likely to choose car sharing.

(10) Price affected the willingness to use car-sharing with a negative coefficient. It can be concluded that the

increase in car-sharing service price could reduce the customers' willingness to use it, by approximately 0.46%

V. Conclusion and Discussion

This paper examined the probability and the influencing factors of the intention to use car-sharing services in Bangkok. Through multiple linear regression, the significant factors towards the intention to use car-sharing included mode of transport, travel purpose, walking distance, ride-hailing experience, car-sharing experience, the expected purpose of using car sharing, expected reason using car sharing, and price of the service. In greater details, the people who drive have more probability to choose car-sharing than other modes of travel. This was not in accordance with the previous studies of [5, 11, 15-16] that car sharing is attractive to people who travel mainly by public transport. The reason may be because the drivers have been facing traffic problems, such as traffic jams and insufficient car parks, which caused stress on the road. Besides, they also hold the cost of vehicle ownership. Therefore, they may want to eliminate these problems by using car-sharing.

The results showed that the people who travel for work or study tend to be more willing to use car-sharing than the people who travel for shopping. This is inconsistent with the study of [4], which found that the users traveling for work purpose are less willing to switch to car-sharing. Moreover, reference [15] found that people who use taxis for their social activity tend to use car-sharing. Therefore, in the context of car-sharing in Bangkok, the drop points of car-sharing should be located near the offices or universities in order to satisfy the target group.

It is reported that walking distance has a significant influence on the use of car sharing. Whether the walking distance from home, office or university to car-park or bus stop, the longer distance they had to walk, greater the likelihood of car sharing. The result was coherent with expectation, people tend to satisfy a motorize vehicle if they have to walk in a long distance. Thus, the walking distance to the car-sharing stations should be as short as possible, which means a number of sites covering all area are need.

The experience of using mobile-app taxi or ride-hailing services also impact to the customers' intention to use car-sharing. People who were familiar with mobile-app taxi services tend to be more willing to use car sharing. Similarly, the people who have experience of using car sharing were more likely to use car-sharing. As expected, people who are open-minded to new technology were more disposed to try new things.

The people tend to use car sharing for work or study rather than travel or relaxation. Also, people will use car sharing to replace the current transport mode. The findings were different from the previous study of [8] which found people were likely to use car-sharing for leisure or personal purposes.

The waiting time for shared-car availability also influenced the intention to use car sharing. People who had more patience to wait tended to be more likely to use car sharing. The average longest waiting time was about 19.52 minutes, which was consistent with the study of [20] that found people willing to wait approximately 15-20 minutes for a shared car.

As expected, price of the service affected the probability of using car-sharing. It confirmed the previous literature that when the cost of car-sharing increased, the probability of car-sharing decreased [9, 12, 14, 20].

TABLE V. Results of the multiple linear regression analysis

	B	Std. Error	t	Sig.	VIF
(Constant)	3.969	1.022	3.885	0.000	
Mode of travel: Private car (as a passenger)	-1.724	0.372	-4.638	0.000	1.583
Mode of travel: Public transport	-0.998	0.311	-3.205	0.001	1.650
Travel purpose: Shopping	-0.919	0.450	-2.042	0.042	2.531
Walking distance from home to car park or bus stop	0.001	0.000	2.092	0.037	1.488
Walking distance from office to car park or bus stop	0.001	0.000	2.656	0.008	1.902
Ride-hailing experience	1.192	0.275	4.341	0.000	1.796
Car-sharing experience	1.692	0.414	4.091	0.000	1.393
Expected purpose for using car sharing: travel or relaxing	-0.875	0.258	-3.391	0.001	1.542
Expected reason to use car sharing: Connecting other modes	-0.741	0.265	-2.793	0.005	1.798
Expected reason to use car sharing: Other reasons	-3.718	0.701	-5.301	0.000	1.615
Acceptable longest waiting time	0.024	0.009	2.774	0.006	1.237

for shared-car availability					
Car-sharing service price	-0.029	0.006	-5.017	0.000	1.000

TABLE VI. Marginal effect of each variable

Variable	Marginal Effects ($\frac{dy}{dx}$)		
	Average	Max	Min
Mode of travel: Private car (as a passenger)	-0.277	-0.009	-0.431
Mode of travel: Public transport	-0.160	-0.005	-0.250
Travel purpose: Shopping	-0.148	-0.005	-0.230
Walking distance from home to car park or bus stop	0.000	0.000	0.000
Walking distance from office to car park or bus stop	0.000	0.000	0.000
Ride-hailing experience	0.191	0.298	0.006
Car-sharing experience	0.272	0.423	0.008
Expected purpose for using car sharing: travel or relaxing	-0.140	-0.004	-0.219
Expected reason to use car sharing: Connecting other modes	-0.119	-0.004	-0.185
Expected reason to use car sharing: Other reasons	-0.597	-0.018	-0.930
Acceptable longest waiting time for shared-car availability	0.003853	0.006	0.000119
Car-sharing service price	-0.00466	-0.00014	-0.00725

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